M/035/015

State of Utah

DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF WATER QUALITY

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May 16, 1996

Mr. Robert E. Dunne, Project Manager
Tailings Modernization Project
Kennecott Utah Copper Corporation
11984 West Highway 202
Magna, Utah 84044

Dear Mr. Dunne:

Subject: Review of Appendix A - Assessment of Acidification Potential - Kennecott Tailings Impoundment; Ground Water Discharge Permit No. UGW350011

The review of the Assessment of Acidification Potential monitoring plan that was received on February 21, 1996, has been completed. The following reflects comments received from representatives of the Division of Oil Gas and Mining , our consultant Gene Farmer, and myself. We have also considered the discussion entertained with your staff and consultants in our meeting on April 16, 1996.

One of the main items of discussion during our April 16 meeting, was identifying the objectives of the monitoring program. The following are some overall objectives that the monitoring plan should meet in order to address the requirements of compliance condition No. 4 in the ground water discharge permit and the reclamation standards of DOGM:

- Accurately quantify the acidification that will occur on the impoundment, both in a lateral extent, and in the degree of acidity, (i.e. soil pH) to allow DOGM to assess if the reclamation proposed for the impoundment will prevent or minimize wind and water erosion through the establishment of a diverse and self-sustaining vegetative community that is suitable for the proposed post-mining land use of wildlife habitat. Some of these same issues will need to be addressed to satisfy the requirements of compliance condition No. 9 (Final Closure) in the ground water discharge permit.

- Assure the Division of Water Quality that any discharges from the tailings impoundment will not migrate into or adversely affect the quality of any other waters of the state, including surface water quality standards, and that any discharges are compatible with the receiving ground water. The degree of acidification that will occur will determine the concentration of many pH sensitive metals species.

- Further quantify acidification potential to determine if the controls proposed (spot treatment with lime) are appropriate or if additional control measures will be needed to achieve a stable and environmentally acceptable final closure.

- Present a statistically sound characterization of acidification potential for the different units of both the existing and expansion portion of the Tailings Impoundment.

Specific Comments and Deficiencies

3.1.1 Sampling Locations

Sampling will be required in four primary areas and five secondary areas as follows:

1. Interior Surface of Existing Impoundment

    a) Copperton Concentrator Tailings
    b) Magna Concentrator Tailings
    c) Slag Tailings
    d) Power Plant Ash
    e) Hydrometalurgical Plant flows

2. Embankment of Existing Impoundment

3. Interior Surface of Expansion Portion of Impoundment

4. Embankment of Expansion Portion of Impoundment

Existing Impoundment - Interior Surface

The existing inflows to the impoundment need to be sampled, starting summer 1996, to provide characterization of the interior surface of the impoundment. The intensity of sampling should reflect the relative proportions of the inflows. The objective here would be to more fully characterize the final surface of the existing impoundment unless changes are made between now and placement of the final layer of tailings prior to reclamation. At this time, only four samples from the interior surface area of several thousand acres have been analyzed. Information gained from sampling existing inflows will be used to assess the proposed reclamation plan and determine if any operational changes need to be made prior to placement of the final layer of tailings.

Existing Impoundment - Embankments

Kennecott has provided results from 17 transects of the existing embankment (52 sampling locations at two depths; 104 total samples). The results from these samples indicate that from 20 to 30% of the embankment will show some acidification. This collaborates with visual observations on the embankments to date. The remaining acidification potential of these areas needs to be quantified. Kennecott has proposed spot treatment with lime amendment to address this issue. The samples from the embankment have been grouped into upper, middle, and lower classifications. Based on the statistical calculations in addendum No.1, additional samples will be needed for the middle and lower portions of the existing embankment.

Expansion Portion of Impoundment

Kennecott has proposed four samples per year from the cyclone underflow materials to characterize the approximately 6 mile long, 200 + foot high embankment of the expansion portion of the impoundment. No sampling of the overflow materials is proposed that will constitute the 3000+ acre interior area of the expansion portion of the impoundment. In addition to sampling the underflow (coarse material) from the cyclone stations, samples of overflow (fine material) that will constitute the surface of the impoundment must be included in the plan. The objective is to assess with some certainty, what the acidification potential of the 3000+ acre interior area of the expansion portion of the impoundment will be, and to assess the adequacy of the proposed reclamation plan to determine if any operational changes need to be made prior to placement of the final layer of tailings.

3.1.2 Sampling Frequency

Using commonly accepted variance analysis, the number of samples needed to predict the mean ABA value (within the interval of+10 to- 10 tons/ktons) of the population with a 95% confidence level are as follows:

Unit	Samples Taken [2]	Sample Size Needed for Statistical Adequacy	Samples still needed	Recommended **Annual** Sampling Frequency
Interior Surface of Existing Impoundment	4	Cannot calculate with only four samples	Unknown	12 Copperton (monthly) 12 Magna (monthly) 4 Slag Tailings (qtrly.) 4 Power Plant Ash (qtrly.) 4 Hydromet effluent (qtrly)
Existing Embankment: Upper Section	17	12		none
Existing Embankment: Middle Section	18	72	54	27
Existing Embankment: Lower Section	22	344[1].	322	10[1].
Cyclone Underflow	7	61	54	12 (monthly)
Cyclone Overflow	none	no data		Start with 20 samples (spaced over time) to calculate first estimate of variance

1. Three data points that may prove to be outliers influence the calculated sample size significantly. Additional samples should be obtained to verify if in fact these observations are outliers.

2. See sample selection criteria noted in addendum No. 1.

These samples should be grab type samples rather than composite samples. After each year of sampling, the number of samples needed per year will be assessed and adjusted accordingly.

Kennecott has proposed one kinetic test per year. Kinetic tests should be performed on at least 10% of the ABA samples from each unit. After the initial round of sampling, this frequency can be adjusted based on results.

3.1.3 Testing method and parameters

A formal protocol for kinetic testing must be included in Appendix A. The protocol should include sample selection criteria, lab set up, analytical methods and conditions for terminating the test.

Initially, kinetic testing should be conducted on samples with ABA values between -10 and +10 tons/kton. This will allow assessment of samples within the zone of uncertainty. The range of -10 to +10 tons/kton may be adjusted pending the outcome of the initial rounds of kinetic testing.

The methodology used to calculate ABA values should be specified in the protocol for ABA sampling and analysis.

3.1.5QA/QC Program

The discussion on reference samples is not clear. Please provide an additional explanation of this proposal. What control charts have previously been developed? How will this process work?

4.0 Reporting

An annual report will be needed for 1996 sampling results. According to the requirements of the ground water discharge permit, the annual report is due by March 31 for the prior year's sampling.

Other Items

Protocols for taking samples, sample handling, and chain of custody will need to be included in this plan. Copies of the laboratory analysis for each sample taken will need to be provided along with the annual report (or precede it).

In order to have an approvable plan in time to begin sampling in the summer of 1996, would you please assure that a revised version of Appendix A that addresses the issues noted in this letter is submitted to the Division of Water Quality by June 19. 1996. If you have questions or would like to meet to discuss any issues relating to this plan, please free to contact me.

Sincerely,

John Whitehead

John Whitehead, Ground Water Hydrologist
Ground Water Protection Section

JW:wfm

cc: Wayne Hedberg, DOGM
Gene Farmer

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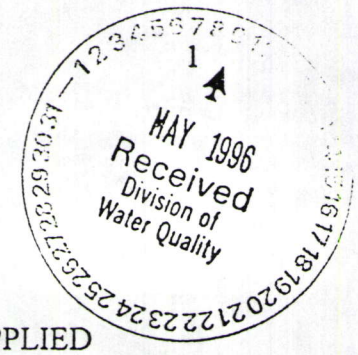

May 7, 1996

ADDENDUM NUMBER 1

AN EXAMPLE OF A SIMPLE STATISTICAL APPROACH APPLIED TO THE KENNECOTT ACID-BASE ACCOUNT DATA SET

Introduction

The purpose of this work was to identify the number of representative samples that might be required to define the sample means in the acid-base account data set, plus or minus 10 tons/1000 tons of waste at a 95% level of confidence. It should be emphasized that these sample numbers are estimates. They are not hard values; they are intended only as guides.

These estimates also imply that the sample values are representative of the population from which they are drawn, in this case the appropriate KUC tailings compartment or location. In addition to considerations of representativeness, it is also necessary to consider other conditions associated with statistical testing of normal populations, such as the collection of independent, random samples.

In the development of the data set for each analysis some rules were established as an aid to minimize bias. Only one value was included for each sampling point. In those cases where multiple values (as many as six) were reported for a single sampling point the value included in the data set was that value closest to zero. This will have the effect of reducing the sample variance. When a single sampling point contained both positive and negative values the negative value was retained.

The ABA values were calculated from the Energy Laboratory sheets provided by KUC using the Schafer and Associates SOP-A1 protocol.

Existing Embankment, Upper Samples

Seventeen sample locations were used in the calculations: T2U, T3U,T5U,T6U, T7U, T8US, T9U, T10U, T11U, T14U, T15U, T16U, T17U, T18U, T19U, T20U, AND T21UB. All data points were included. Missing sample locations were not in the KUC data set.

The resulting ABA data set was : -21, -45, -15, -5, -9, 9, -3, 13, -1, -21, -4, 13, 3, 11, 15, 7 and 1. N = 17.

Sample mean = -3.06
Sample variance = s^2 = 245.56

Stein's Sample Number Estimator

$n = t^2 * s^2 / d^2$

where:

n = the required sample number

t^2 = tabulated F value for d.f. (1,16) at 0.05 probability
s^2 = sample variance
d^2 = half-width of the desired confidence interval, squared

$n = 4.49 * 245.56/ (20/2)^2$
$n = 11.03$ samples
Rounding up $n = 12$

Since we have 17 samples and need only 12, we have enough samples. The mean ABA value of -3.06 is within plus or minus 10 tons/1000 tons of the population mean at a confidence level of 95%. Or, -13 < ABA mean value < +7.

Existing Embankment, Middle Level Samples
All reported sample locations were used, from T1M to T22M. Sample locations 7, 8, 9, and 10 are missing from the KUC data set. The ABA data set is: 34, -6, -4, -6, -9, 154, -5, -17, -4, 18, 24, 7, -12, -36, -1, -8, -12, and -14. N = 18.

Sample mean = 5.72
Sample variance = 1622.09
Stein's estimator = $n = 4.45 * 1622.09/ (20/2)^2$
n = 72 samples.
Since we already have 18 samples, 54 more samples are needed.

Existing Embankment, Lower Level Samples
Twenty-two sample locations were used. The ABA data set is: -4,-2, -3, -11, -12, -8, 161, -1, 260, 4, -4, -10, -29, 288, 90, -22, 30, -4, -9, -19, -16 and -5. N = 22.

Sample mean = 30.64
Sample variance = 7970.05
Stein's estimator = $n = 4.32 * 7970.05/ (20/2)^2$
n = 344 samples
Since we have 22 samples, we need 322 more samples.
It seems that the values of 161, 260, and 288 might be out of place in this data set. Some effort to determine if these values are real or if they are outliers might be justified.

Cyclone Underflow Samples
The data set consists of 7 values from tailings simulated for testing purposes. The ABA data set is: 15, 13, -4, 7, -75, 9, and 4. N = 7.

Sample mean = -4.43
Sample variance = 1007.29
Stein's estimator = $n = 5.99 * 1007.29/100 = 61$ samples
Since we have 7 samples, we need 54 more samples.

Existing Impoundment, Interior Surface Samples

This data set consists of four ABA values. The data set is: 5, 14, 9, and 13. It is not appropriate to calculate Stein's estimator on this data set since these data cannot be considered representative of the interior of the existing tailings impoundment which consists of 4000 to 5000 acres of tailings.